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ABSTRACT

In 1993, a team of seven researchers at the University of South Australia investigated student diversity among its population in relation to the curriculum in action, student experiences of exclusion and inclusion, and staff experiences of attempting to understand and counter exclusion. This paper reports on a case study based on the newly developed set of integrated mathematics and science subjects within the Bachelor of Teaching program. Students had identified these subjects as increasing their understandings of, and success in, mathematics and science as they prepared to become elementary school teachers. The research: (1) describes the underlying principles and approaches adopted by staff; (2) describes and analyzes student perceptions of their learning experiences; and (3) explores issues which impinge upon planning and teaching for "inclusivity" of student diversity. The paper outlines broad findings of the research, critically examines what it might mean to plan and teach for "inclusivity" and "empowerment" within preservice teacher education, and pays particular attention to prior learning and assessment. Appendixes provide categories for coding student answers and the mathematics and science backgrounds of the students. (Author)

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Empowerment and inclusivity: a case study of mathematics and science curriculum in pre-service teacher education

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Paper prepared for ATEA 24th Annual Conference
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Abstract

In 1993 a team of seven researchers at the University of South Australia investigated the student diversity among its population in relation to the curriculum in action, student experiences of exclusion and inclusion, and staff experiences of attempting to understand and counter exclusion. [1]

This paper presents the findings of one pair of researchers who undertook a case study of a newly developed set of integrated mathematics and science subjects within a Bachelor of Teaching. Students had identified these subjects as increasing their understandings of, and success in, mathematics and science as they prepared to become junior primary and primary teachers.

The research:

- describes the underlying principles and approaches adopted by the staff
- describes and analyses student perceptions of their learning experiences
- explores issues which impinge upon planning and teaching for "inclusivity" of student diversity

The paper:

- outlines the broad findings of the research
- critically examines what it might mean to plan and teach for "inclusivity" and "empowerment" within pre-service teacher education
- pays particular attention to prior learning and assessment

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[1] This work, edited by Jenny Barnett, is to be published as **Working with student diversity: contexts, issues and strategies** by the Centre for University Teaching and Learning (CUTL), University of SA, The Levels Campus, Warrendi Road, Salisbury 5109

Empowerment and inclusivity: a case study of mathematics and science curriculum in pre-service teacher education

OUTLINE OF THE RESEARCH

Helen Nixon, School of Communication and Information Studies, Magill and David Roberts, Aboriginal Studies and Teacher Education Centre, Underdale worked on this project during Semester 2, 1993 with Alan Barton, Michael Chartres, Graham Crawford, Lorraine Harker and John Joseph from Studies in Education, Underdale.

The mathematics and science in education study is an ethnographic case study of the educational philosophy and practice of the third year Bachelor of Teaching subject **Investigations 3. Investigations 3** is a final year subject which was taught for the first time in 1993. It builds on and articulates with five other subjects in the mathematics and science strands of the University of South Australia Bachelor of Teaching (Underdale). Along with that whole cluster of subjects, its orientation and content have emerged out of identified needs set out in the Speedy Report to prepare student teachers more effectively in the areas of mathematics and science. To this end staff have elected to pursue an interactive/constructivist approach to their teaching which has sought to be inclusive of students' existing knowledge and experience in mathematics and science. Staff are conscious that students come from a wide range of backgrounds and experience including non English speaking backgrounds (NESB)[2], Aboriginal, mature age, and differing previous levels of achievement in the mathematics/science areas.

Members of the mathematics/science team teaching the Bachelor of Teaching are working in a collaborative way to plan and deliver a set of integrated programs across Years 1-3 of the award. This "integration" includes the integration of mathematics and science *content* into both the **Investigations** and the **Science and Mathematics Education** subjects and the integration of *approaches* to the teacher education students' own learning and their learning about the business of teaching. The team aims to present a three year program which is developmental, coherent theoretically and theorised consistently in terms of educational philosophy about teaching and learning.

The **Investigations** subjects focus on helping the university *students' own* learning of mathematics and science concepts, whereas the **Science and Mathematics Education** subjects focus on *children's* learning of mathematics and science.

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[2] The categorisation of students as NESB is, of course, problematic in itself as it can be interpreted as a signifying deficit. Other terminology such as second language students may be more appropriate.

The research project was conducted over several phases and had the following aims:[3]

- To establish the underlying principles and approaches adopted by the staff in the organisation and teaching of **Investigations 3**.
- To attempt to describe and analyse student perceptions of their learning experiences in **Investigations 3**.
- To explore issues emerging from the study which impinge upon planning and teaching for "inclusivity" of student diversity.

To gather and analyse the data for this study the researchers referred to all available documentation, conducted interviews with staff and students, observed classes and staff meetings, and analysed students' written work. The researchers read 57 assignments out of a potential 95 assignments and 45 of these were coded according to the categories outlined in Appendix A.

Twenty one students were interviewed, five from one workshop group and four from each of the other four workshop groups. The sample constituted just over 22% of the total enrolment in **Investigations 3**. Four of the students were of non-English speaking background, one was Aboriginal, five were mature age students, and five were male. The interview data was coded, analysed and cross checked by the researchers. The analysis was then returned to the students for comment and verification.

In most cases both researchers were present for observations and interviews and they were able to test their observations out on each other. In addition these observations were "fed back" to all the mathematics and science staff involved in **Investigations 3**, both formally and informally, for their comments.

BROAD FINDINGS

1. Some key underlying principles and approaches of the staff

- Lecturers are concerned to bear in mind principles and practices of "inclusivity" in their course planning and teaching.

  '... in **Investigations** we're saying to students 'we're going to investigate these major concepts in mathematics and science that you already would have an idea about, and we'll take you from where you are to somewhere else, and somewhere else will be different for different people in the group.'

- Classes should be interactive and exploratory in nature allowing students to move from their present levels of knowledge and experience to greater understanding. To this end the mathematics science staff work on an interactive/constructivist learning model and workshop format rather than a lecture and tutorial format.

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[3]For a fuller report on this research see Barnett, Jenny et al, **Working with student diversity: contexts, issues and strategies** (forthcoming) Centre for University Teaching and Learning (CUTL), University of SA

'We wanted it to be workshop based all the way through. We wanted it to be based on their doing activities and then reflecting on those activities.'

'... even though we're exploring a lot of mathematics and science from a conceptual view, we're also modelling that we want to find out what the students' prior knowledge is. We want to be able to seek that knowledge in a context that they can work from, and that means using appropriate vehicles.'

- Lecturers believe in the importance of talk in learning and the benefits of collaboration. To this end students are encouraged to work collaboratively not competitively, working in pairs and small groups in classroom activities.

  'But when they've got a bit of time to reflect with other people, they do clarify their own problems, and they become very good at it too. And that is, I think, one of the big changes I've seen in the students. They are very good at working out what it's about, and how they can begin to attack that problem. And that's been pretty important.'

- Lecturers aim to help students find out and value what they do know and apply this knowledge. The **Investigations** subjects emphasise students' development and understanding of their *own* learning rather than the learning of their future students. Staff believe that it is important for students to discover and reveal what they *do* know and also areas of uncertainty. In **Investigations 3** the emphasis in class work and assignment work is on students' uncovering knowledge about the ways in which they learn, the **processes** they undergo to help them learn, and so on. Students are encouraged to reflect on what processes led them to draw certain conclusions and posit certain theories.

- Assessment in **Investigations 3** is made largely on the basis of what students report about their reflections on their journey, the way their "thinking as they went" affected what they did and what they have learned. Students are assessed on assignments which they individually prepare. There is no group assessment or formal assessment of participation in workshop activities. Assignments are graded according to the university system of summative assessment using the notations High Distinction, Distinction, Credit, Pass 1, Pass 2, Fail.

  Assessment is based on the quality of students' written reflections on their emergent understanding of the "big issues", which may for example be finding relationships which remain constant across a series of examples when exploring the relationship between the diameter and the circumference of a circle.

2. Students' perceptions of their learning experiences in Investigations 3

Student assignments

In analysing a large cross-section of students' first assignments in **Investigations 3** a significant number of the students, 60% of the sample, expressed the view that they had acquired increased understanding of the concept of "modelling" which had been the topic of that section of student

work. At least half of the students in the sample did present what was "required" of them by way of expressed "increased understanding" as a result of doing the activities, the "valuing" of the use of concrete materials and examples, and expressed "positive" feelings about what they had done in class and what they might do in their own future classrooms.

What it is not possible to ascertain from this analysis is the extent to which the expressed student views and feelings are potentially "verifiable" and the extent to which the responses are merely employing a form of routinised "personal voice" in keeping with the "genuine" and "honest" process and reflection genre which is encouraged by the assessment guidelines. This issue of what might be called the "personal response" or "reflection" genre in **Investigations 3** assignments was followed up in student interviews.

In **Investigations 3** the staff are concerned that students connect their learning with their life experiences. Several anecdotes in the assignments showed that some students at least were looking at their own world slightly differently as a result of their workshop experiences.

> 'A few days after the session on bacteria one of my friends from Sizzler asked me if bacteria doubles every second (he provided examples) and it takes 30 seconds to fill up a jar how long would it take to fill up half a jar? My answer of 29, which is correct, made me realise how much I learnt during the session. According to him I am the first person to provide the correct answer. As a result I decided to investigate the problem further.'

> 'I have also recently found myself working out which pizza menus to keep and which to throw out and which size pizza is the best value for money to buy based upon the diameter size they provide on the price list. Who would have thought four weeks ago that I would be interested to see if Pizza Hut's new big value rectangular pizza was really big value compared with the good old fashioned round variety for reasons other than economic? Certainly not I.'

Student interviews

Most students compared the mathematics/science subjects favourably with other subjects in their Bachelor of Teaching award. Students commented on their participatory hands on nature, their relationship with the classroom and teaching, the gaining of skills and knowledge that they could use in their teaching, and on group work. Other subjects that they identified as having similar features were Music, Drama and Physical Education. Many of these students contrasted the **Investigations** and **Science and Mathematics** groups of subjects favourably with a number of other subjects in their course where 'lecturers tell us what to do and how to do it' and 'don't practice what they preach.'

The data provided by students indicates that the staff have had a large measure of success in achieving their objectives. The students reported that the workshops enabled them to utilise not only their own existing knowledge and life experiences, but also those of their peers. They were able to gain insights into the perspectives of others, value others' views and re-examine their own existing ideas. The emphasis on group work in particular provided students

with the capacity to support each other, fostered opportunities to work together cooperatively and facilitated peer learning.

Many students who were interviewed for the mathematics and science education study stated that they would like *explicit* references to the rationale for the inclusion of content and for the use of a particular kind of teaching methodology. That is, the study alerts the university community to the fact that what staff understand to be a *demonstration* of the assumptions on which a subject is based may not be recognised or understood as being so by the students.

It is significant that all the students interviewed were able to identify ways in which they had found **Investigations 3** useful to them. What was identified as useful, however, varied considerably across the students, reflecting their different needs, expectations and experiences in the subject. Such differences serve to highlight the complexities and problems that staff encounter as they seek to cater for all students in their endeavour for inclusivity.

In brief, some of the issues relating to inclusivity specifically addressed by staff include:

- taking account of prior learning and prior knowledge of mathematics and science
- acknowledging and understanding some of the diversity in the student population, including socio-economic status, gender, Aboriginality, non-English speaking background students, sole-parent students, mature-aged and youthful students
- assessment

Some of the issues specifically addressed by students include:

- the expectations they bring to subjects
- differing teaching and learning styles in both university and school settings
- assessment

The findings will not be discussed in detail here. Rather, several of the issues listed here will serve as the basis for further discussion.

PLANNING AND TEACHING FOR INCLUSIVITY

The wider project in which this study is situated[4] generated some broad research questions. Some of these were:

- How do students experience exclusion?

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[4] See Barnett, Jenny et al, **Working with student diversity: contexts, issues and strategies** (forthcoming) Centre for University Teaching and Learning (CUTL), University of SA

- What characteristics of university culture are linked with student exclusion?
- What strategies are university staff using to address issues of inclusivity, and in regard to what elements of teaching and learning?
- What have been the issues and outcomes associated with these strategies?

The first two questions required the researchers to look at courses where staff involved had observed that exclusion was occurring. The following two questions required us to look at courses where staff were addressing inclusivity in one form or another. The mathematics and science education subjects, the **Investigations** and **Science and Mathematics** group of subjects, were originally chosen for study because they were seen by staff to be specifically addressing issues of inclusivity and had been reported by Aboriginal students as being very supportive of their learning needs in ways in which their previous experiences of mathematics and science had not been.

The following are some factors the mathematics and science education research suggests the teaching team saw as being important in developing and teaching "inclusive curriculum" in their subjects.

- students' prior learning and knowledge is the beginning point for inclusion of students into the curriculum
- group work facilitates a cooperative, negotiable approach to learning in which students' differing prior learnings can be valued
- it is important to acknowledge and understand some of the diversity in the student population, including socio-economic status, gender, Aboriginality, non-English speaking background students, sole-parent students, mature-aged and youthful students
- starting from students' different needs, experiences and expectations leads to different outcomes

Some discussion will be made of these points.

Prior learning as the basis for inclusive curriculum

Embedded in the notion of inclusivity held by staff in their teaching of **Investigations 3** was the importance of recognising and building on from students' prior knowledge. Staff were aware that a considerable range did exist in their classes, ranging from students with Year 12 or even tertiary studies in mathematics and/or science related subjects to those who have little formal learning background in these areas.

There are, however, many problems related to the establishment of just what it is that a diverse cohort of students might bring with them to the classroom. Our study suggests that further research needs to be done in the area of how staff might establish the "entry points" in any subject which are likely to be **accessible** by a diverse range of students. How might such inclusive "accessibility" or suitability of "entry point" for a range of students to a topic in

mathematics and science be validated? If the learning objective is for students to "to move from one point to another" in their understanding of a topic, and if they have begun from very different points, what exactly is being "measured" and how can it be done equitably?

In teacher education there is a further complexity in that individual student achievement or "progress" - that is their "moving from one point to another" - might not be an outcome which equips students for their role as student teachers and teachers . Might there be some kind of minimum competencies which need to be demonstrated? In our study, for example, while many of the students had indeed built up their confidence and were theorising about mathematics and science, some students felt that they lacked sufficient knowledge about mathematics and science to equip them for teaching. Some students were concerned that they, or some of their peers, would be going out to schools and teaching concepts with which they were not sufficiently familiar. This tension between individual improvement and benchmarks or competencies is not an easy one to accommodate in inclusive curriculum.

Prior experience and socio-cultural background as the basis for inclusive curriculum

Establishing where students "are beginning from" may require more than establishing students' prior learning and knowledge of the subject area. Knowledge about other factors of the "placement" or "location" of some students in relation to other indices, such as non-English speaking background, may also be necessary in order to develop inclusive curriculum. That is, diversity and difference within the classroom may be much broader than we first think and might impact on student learning in ways we do not yet know about. In addition, socio-cultural assumptions are often embedded in what we do in ways which are difficult to identify and articulate and therefore difficult to make explicit for our students as the basis of inclusive curriculum in our courses.

Gender

As part of their attempt to connect with students' lived experiences the **Investigations 3** teaching team endeavoured to use examples which they believed to be as "true to life" for their students as they could possibly be. During planning meetings about a proposed topic of work in mathematics on "area", for example, members of the team discussed the use of such examples as calculating the amount of fertiliser to put on the lawn, the amount of paint to buy to cover rooms of certain dimensions, how much gravel to order to cover the drive way, how much gyprock to buy or how many bricks to order when building a wall, and so on.

As they worked through these possibilities the teaching team commented on these as being "masculine examples". They then cast around to find an "alternative" example to give. An initial suggestion, the calculation of the

amount of material required to sew a garment, was deemed to be both stereotypical and inappropriate for the purpose of the topic. The end result of the discussion was to abandon the topic of "area" and adopt a less problematic one in terms of developing gender inclusive activities.

This example illustrates the difficulty of breaking out of stereotypical views of gender, despite one's best intentions. It is obviously important that we challenge amongst themselves, and with our students, the socio-culturally based assumptions embedded in our discussions about any topics of study in our courses. In mathematics, for example, "area" might be a concept useful to the white, middle class, employed suburban home buyer but may be a foreign or useless concept in many other socio-cultural settings.

Further, the value placed on certain subjects like mathematics or art or nutrition are themselves gendered and culturally based. We still need to find out more about how we can make such understandings an integral part of teaching and learning within teacher education.

Socio-economic status

The staff in our study showed awareness, concern and sensitivity about another index of difference, socio-economic status, in their planning to set up learning activities for their students. For example, in order to connect a new concept of networking with students' lives, staff discussed the use of the example of a network to help students explore "best ways" to get from point A to point B when travelling. (Students were to be encouraged to explore some of the assumptions about what it is that the "best way" might possibly mean, for example it might mean the cheapest way, the fastest way, the most energy efficient way, and so on). However, as they planned the staff soon articulated an understanding that their first idea for conveying the concept of networks might *not* be one which "connects" with the lived material realities of students' lives.

They had suggested, for the network, using examples of advertised cheap air fares between capital cities in combination with hire car travel between major cities and smaller towns. They then came to a discussion of alternative examples which might be more appropriate to the lived experiences and economic circumstances of their students. These included using the published routes and fares from *bus* companies rather than airlines. That is, the staff wished to incorporate into their workshop activities a recognition that their students were largely living in low-income circumstances.

When staff discussed the inclusion of a section of work on "interest", they discussed using examples of personal loans and mortgages and what this content might "mean" for their students. Discussion ranged, for example, over whether or not to include comparisons of renting and buying a home. Staff were aware that there are equity issues here, one of them saying quite clearly that 'they see it all on tele - have this, buy that - but they know they don't have access to it.'

Such examples are useful in suggesting ways in which staff might not only grapple with these issues in their planning but might also use them as teaching points for their students. That is, we can model and make explicit for our students examples of the socio-cultural issues and dilemmas likely to face them in their own teaching.

Students from non-English speaking backgrounds

Interviews with students in our study who had non English speaking backgrounds (NESB) showed that some students were surprised that this was being recognised as an issue which might affect their learning. Some expressed reluctance to "expose" what is socially perceived as "difference" in what they bring to the classroom. When invited to discuss this aspect of their background further, students discussed quite freely such matters as their bi-lingualism, the situations in which they spoke different languages, the ways they were able to use this aspect of their background in the community, how it had been or might be put to use in school settings, and so on.

In relation to how this aspect of their background impinged on their success in **Investigations 3**, students felt that it made it more difficult for them to succeed, largely due to the existing assessment practices. Assessment was based totally on written assignments which required significant facility with English if students were to be able to discuss the full complexities of their "reflections on their learning". NESB students all identified that writing about what they had experienced was very difficult for them. They felt that they did not have sufficient grasp of the forms and vocabulary of English to express clearly the reflections they were making on their learning. Interestingly the issue of assignments being heavily dependent on fluency in written English had been raised and acknowledged as an issue in an early staff meeting, was discussed a number of times but remained unresolved.

Assessment practices in an inclusive curriculum

Assessment in **Investigations 3** is made largely on the basis of what students report about their "reflections on their journey", the way their "thinking as they went" affected what they did and what they learned. Most of the students interviewed in the study felt that the assessment tasks were consistent with the subject's aims, objectives and approach. They mentioned that it helped them focus on their own learning - what they thought about a topic and the kinds of issues and changes that they had worked through as they investigated the topic.

Much more could be said about the assessment of "process" and "reflective writing" and how this might be linked to "empowerment" than is possible in this paper. The problematic of the nature of empowerment - including empowerment for what, empowerment for whom and empowerment according to whose judgement - will be thoroughly discussed throughout this conference.

One major finding from the mathematics and science in education study is that students reported that they found reflecting on their learning in the assignments difficult to write. Often the difficulty was due to the nature of the task being one with which they felt unfamiliar and, in some cases, where they felt that there was insufficient guidance as to what was required of them. Some of the students found the idea of **reflection** a difficult concept to grasp.

> 'What do they want us to write about? Its just hit and miss, I don't like that feeling.'
>
> 'Lots of times I don't have any understanding of what we've done - I don't know what our actual objectives were. How do I write about that?'
>
> 'The requirements of assignments need to be set out more clearly. It is assumed that you know what to write. I don't.

A premise of many teachers working for inclusivity is that **group work** is a valuable methodology because it facilitates a cooperative, negotiable approach to learning in which students' differing prior learnings can be valued. This view is supported by interviews with students. On the other hand, when a subject is taught in this way but there is no group assessment or formal assessment of participation in workshop activities, and students are assessed on assignments which they **individually** prepare, the contradictions are obvious. If starting from students' different needs, experiences and expectations produces different outcomes, then what are the implications for students when these outcomes are assessed using a norm-referenced or criterion referenced model?

Some key questions for consideration include:

- How can the educational-theoretical basis of a course or unit of work, for example choice about teaching and learning methodology (the use of group work; the use of a "hands-on" approach) be made explicit to students and be an integral part of the "teaching and learning" of the unit?
- Is it possible to reward "process", or what could be described as formative assessment tasks using summative assessment practices?
- Should an inclusive curriculum include differential assessment practices as a way of valuing "difference" in the student group?
- How might differential assessment practices work within a credentialling institution such as the university?

CONCLUSION

All the case studies in the University of South Australia inclusivity project suggest that to be inclusive of our students we need to recognise the multi dimensional and interconnected nature of diversity. To cater for the diversity of student socio-cultural backgrounds, prior knowledge, preferred learning styles, expectations and needs is a highly complex and relatively under-researched area.

We need to know more about how to make our curriculum and the basis upon which it is designed and presented explicit and meaningful to the range of students in our classes. Further, attitudes about learning and what constitute a demonstration of success as a learner are philosophically and culturally based. If "empowerment" is on the agenda in a teaching and learning situation, different beliefs and expectations need to be articulated as part of ongoing dialogue and the implications of these differences need to be discussed. It is especially important for us to research these areas further when we are in the business in pre-service teacher education of educating the future educators.

Appendix A: coding of student answers to Investigations 3 assignment 1, 1993

Categories for coding		N= 45
Initial impression of activities	daunting	2
	new experience	2
	did not know where to start	8
	got me interested	17
Reference to prior knowledge	mention only	16
	positive	10
	negative	8
Explains steps undertaken	in detail	15
	outline	23
	patchy	6
	not at all	1
Own learning	discovery	16
	achievement	9
	greater understanding	22
	stress	1
	frustration	6
	know less now	12
Observation and exploration		7
Prediction		27
Experimentation		20
Testing for verification		21
Recording		2
Use of concrete materials	mention only	3
	helpful	28
	unhelpful	1
Relating abstract to concrete	mention only	6
	positive	25
	negative	4
	selective	2
Relating experiences to teaching	mention only	2
	positive	26
	negative	0
	selective	5
Activities set	too easy	1
	too difficult	3
	interesting	10
	boring	10
Self effacing comments		2
Working in groups	mentions only	2
	positive	4
	negative	1
Value of sharing findings with others	mention only	1
	positive	6
	negative	2
Modelling	understands concepts	37
	refers theory to model	26
	refers materials to model	26
Activities to formula	mention only	4
	increases understanding	26
	healthy scepticism	13

Appendix B: mathematics and science backgrounds of the students

Data gathered from the students provided the following detail concerning the level to which and the nature of their studies in mathematics and sciences at school. It is significant to note that very few had done Mathematics I, II, or IS, only one had done Chemistry and two Physics at Year 12. Of those who had taken Biology in Year 12 most had studied the school assessed (SAS) subject rather than the publicly assessed subject.

Overall it was apparent that students did not have a strong school background in mathematics and sciences, especially the "hard" sciences.

Mathematics background

15 had done either Business Mathematics (9) or Mathematics 1S in Year 12

1 had also done MA I and MA II (plus Business Maths in Year 13)

2 did not state the level of mathematics studied - both these students lacked confidence in mathematics

2 identified Year 11 as the last in which they studied mathematics (I and II) - both were comfortable and confident in mathematics

I had done mathematics to Year 8 - and was decidedly lacking in confidence

I had done mathematics to Year 10, but had, through mature entry, undertaken Business Studies and Computer Studies and was confident.

Science background

1 student had undertaken Physics and Chemistry at Year 12 and one other Physics at Year 12

12 had studied Biology at Year 12 (mostly SAS)

2 identified having done Chemistry at Year 11

3 identified having very limited science backgrounds from their schooling

3 went as far as Biology in Year 11

2 did not identify the level of science reached at school

2 other students were taking the science major in their Bachelor of Teaching

Only 8 of the students felt confident in science (all of these had studied either Biology or Physics and Chemistry at Yr 12)

1 mature age student said he was 'not threatened' by science, and had a "layman's" knowledge and interest in it'

Of those who indicated they were less confident in science five had taken Biology at Year 12 and few seem to have studied Physics or Chemistry in Year 11.